

gain is offset by higher receiver noise and losses from antenna roughness and pointing. This currently limits the net improvement to about a factor of four.

Nevertheless, this factor-of-four improvement represents an enormous value. For instance, we may use Ka-band to acquire four times as much data as at X-band, or track four times as many spacecraft, without building additional DSN antennas (about \$25 million for each 34-m-diameter antenna). The cost avoidance alone could equal that of three new DSNs. Alternatively, we can build smaller and cheaper spacecraft flying smaller antennas and transmitters.

The first deep space Ka-band link experiment flew on Mars Observer (MO/KaBLE), launched in November 1992. Although its 33.7 GHz frequency was outside the DSN allocated band (31.7–32.2 GHz) and its effective isotropic radiated power (EIRP) was only 50 dBm, it was successfully received at DSS 13 up until MO was lost on August 21, 1993.

### **KaBLE Flight System and Components**

Just as MGS was designed to complete the MO mission, KaBLE-II is designed to complete and exceed the objectives of KaBLE-I. The EIRP at 76 dBm is 26 dB

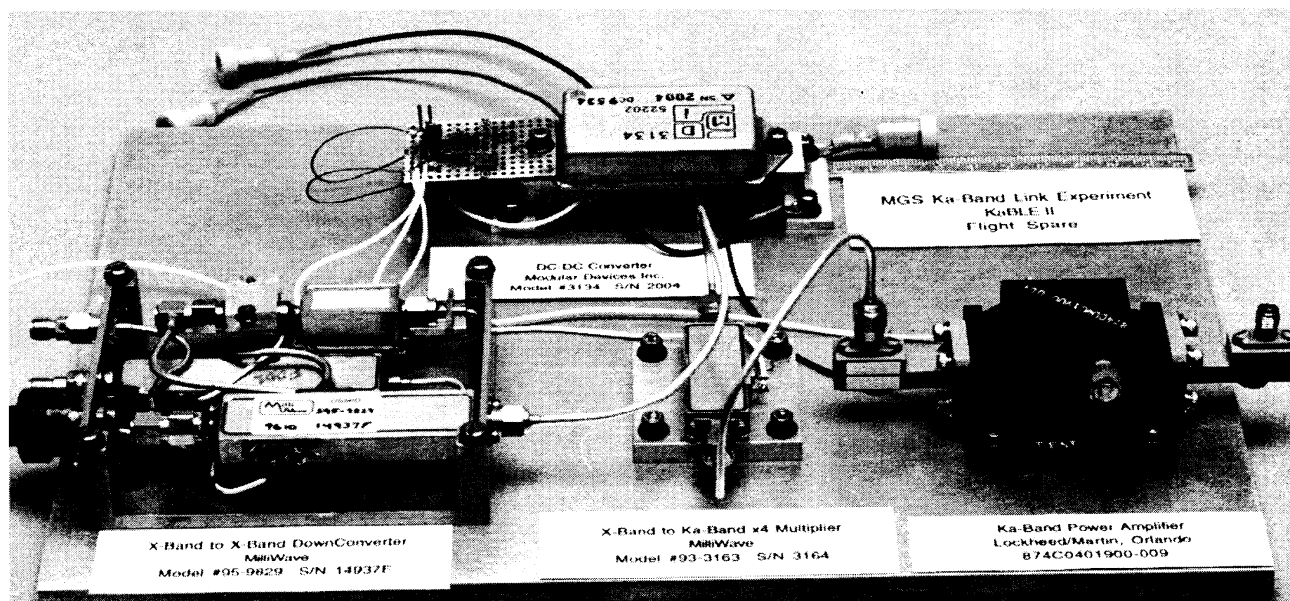
higher (400 times stronger) than on MO, the 32 GHz signal is now in the middle of the DSN-allocated band, and the signal can be turned on/off independent from X-band. Flight components are shown in Figure 3.

The higher EIRP comes from two important advances over MO/KaBLE; a 1-W, solid-state power amplifier vs a 30 mW varactor diode, and a dual frequency X/Ka-band feed. This enabled use of the full aperture of the main reflector on MGS vs using only the subreflector as the Ka-band antenna on MO. Figure 4, shows the MGS high gain antenna (HGA) before installation on the spacecraft. The main reflector and subreflector are spares from MO.

The dual frequency antenna and the 1-W, solid-state Ka-band amplifier were developed by Lockheed-Martin Astronautics (LMA) at Denver, Colorado, who integrated the system under the MGS spacecraft contract.

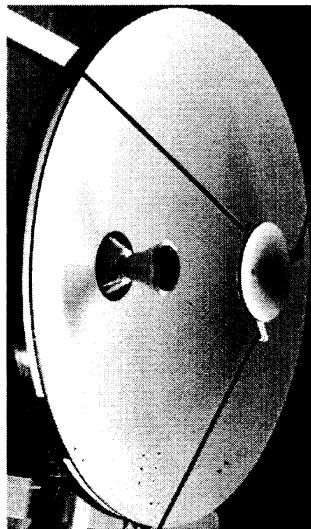
### **Telemetry Ranging and Tracking**

The MGS project will transmit engineering telemetry at 2 kbps over the X-band link during the nine months of outer cruise. The curve in Figure 5 shows there is enough link capability at Ka-band to receive the same 2 kbps telemetry until aerobraking starts. Afterward, during mapping, data rate will be raised to send

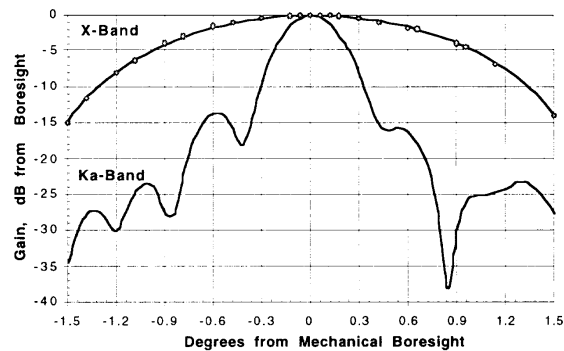


**FIGURE 3. MGS/KaBLE-II FLIGHT HARDWARE**

**FIGURE 4. MGS  
DUAL FREQUENCY X/  
KA-BAND ANTENNA  
GAIN PATTERNS**



Frequency	Gain	Polarization	EIRP
8.4 GHz:	39.0 dBi	RHCP	82 dBm
32.0 GHz :	49.0 dBi	RHCP	76 dBm




science data and it will be too high for the Ka-band link. However, we will still be able to track the carrier signal and monitor link performance.

We also plan to perform ranging and Doppler tracking in conjunction with uplink operations by receiving the X- and Ka-band downlinks at DSS 13.

### Conclusion

While the main objective is to evaluate Ka-band for future operational use, KaBLE will also serve as a test bed for

new Ka-band technology applications, such as low-noise amplifiers, adaptive array feeds to correct antenna deformation, and antenna pointing. Also, it will help check out DSN readiness for the Cassini mission's Ka-band gravitational wave search; MGS will test and provide a checkout of DSS-25, the first operational DSN Ka-band antenna that will support Cassini and NM-DS1. Lastly, the Ka-band signal from MGS may itself facilitate scientific study of the solar plasma, and support sensitive tests of relativistic effects. 

**FIGURE 5. MGS  
KABLE-II LINK PRO-  
FILE SHOWING DATA  
RATE VS. DATE**

